Effectiveness of Compliance With Pediatric Preventive Care Guidelines Among Medicaid Beneficiaries

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ABSTRACT. *Objective.* **Because research has not confirmed a relationship between compliance with health supervision in infancy and improved health outcomes, we examined the association between adherence to prevailing guidelines for periodic health supervision and adverse health outcome indicated by incidence of avoidable hospitalizations.**

Methods. **This was a historic cohort study of 308 131 children enrolled in Medicaid at birth in California, Georgia, and Michigan in 1990 using Medicaid records linked across 3 years. We used avoidable hospitalizations as indicators of health in a survival analysis. The analysis used variables that represented completeness and timeliness of well-child visits and immunizations using AAP guidelines for health supervision as the gold standard.**

Results. **When the children in this cohort were up-to-date for age on their schedule of well-child visits, they were less likely to have an avoidable hospitalization (race, illness, and level of poverty adjusted hazard ratios 0.52 [95% confidence interval (CI): 0.50–0.55] in California, 0.54 [95% CI: 0.50–0.55] in Georgia, and 0.7 [95% CI: 0.69–0.79] in Michigan). Among children who were not up-to-date with well-child visits, a sporadic preventive care visit conferred a mild benefit. Immunizations and race/ethnicity had no consistent relationship with incidence of avoidable hospitalizations.**

Conclusions. **A series of well-child visits maintained during the first 2 years of life has a positive effect on health outcomes as indicated by a decrease in avoidable hospitalizations among poor and near-poor children, regardless of race, level of poverty, or health status. National efforts to improve the quality of child health services for young children should focus on increasing compliance with periodic preventive care for young children in addition to improving immunization levels.** *Pediatrics* **2001;108:90–97;** ***well-child care visits, immunizations, preventive care, compliance, Medicaid.***

ABBREVIATIONS. AAP, American Academy of Pediatrics; MSIS, Medicaid Statistical Information System; HCFA, Health Care Financing Administration; SMRF, State Medicaid Research Files; CPT, Current Procedural Terminology; *ICD-9, International Classification of Diseases, Ninth Revision*; DPT, diphtheria, pertussis, and tetanus; OPV, poliovirus vaccine; MMR, mumps, measles, rubella; HiB, hemophilus influenzae type B; AFDC, Aid to Families with Dependent Children; HR, hazard ratio; CI, confidence interval;

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The health of children as measured by infant mortality and other measures such as potentially avoidable hospitalizations is improving for all, but it is not improving as quickly for the disadvantaged.[1] Early health supervision, beginning at birth, purposely is frequent to accommodate the immunization schedule, monitor early development, and provide guidance for parents about what should be done to maintain child health.[2–6] Despite the removal of financial barriers to ambulatory care, children who are insured by Medicaid use fewer preventive services and more emergency services and have higher hospitalization rates[7–10.] Medicaid-covered children are less likely to have a usual source of care, to spend more days in bed, and to have more serious exacerbations of conditions, such as asthma, that are treatable in ambulatory care settings.[8,11,12] Recognizing this, pediatricians focus on establishing a therapeutic partnership between the pediatrician and the family to encourage continuity of care and to provide the family the motivation to participate in the child's care.

The American Academy of Pediatrics (AAP) recommends frequent well-child visits during the first 2 years of life.[4] In response to questions about the efficacy of this recommendation, the AAP issued a public appeal for research on the effectiveness of preventive care in 1974.[3] A quarter of a century later, with the exception of immunizations, the clinical effectiveness of adherence to periodic child care visits has not been demonstrated with certainty.[13,14] The purpose of this analysis was to investigate the association of well-child visits and child health as indicated by acute hospitalization for conditions that may be avoided by having continuous access to health care. The Medicaid database contains detailed records of hospitalizations and use of ambulatory services on as many as half of the children born in some states. This large database provided us with the opportunity to undertake a detailed evaluation of well-child care of children enrolled in Medicaid during their first 2 years of life.

METHODS

Analytic Sample

Medicaid claims data come from states that use the Medicaid Statistical Information System (MSIS). MSIS was begun in the late 1980s in a few states and was the first data available to the Health Care Financing Administration (HCFA) that contained information on Medicaid beneficiaries' use of services. MSIS contains paid bills, is based on a fiscal year, and is organized by the date the bill was paid. For each year and state, HCFA creates a database from MSIS called the State Medicaid Research Files (SMRF). The SMRF

system is organized by calendar year and by date of service use. The SMRF contains a number of databases, including a file of outpatient visits and inpatient stays. Each record in these files contains procedure and diagnostic codes for each service for which there was a claim. An individual child may have many records in a day, because one visit can generate >1 claim. Another file summarizes the year's activity for each child and contains monthly eligibility information (whether a child was enrolled in Medicaid fee-for-service or managed care or not enrolled), age, race, and an annual sum of expenditures.

We drew a sample from the cohort of children who were born in 1990 and enrolled in Medicaid in California, Georgia, and Michigan during their first year of life. We then created a longitudinal analytic file from the SMRF data, linking 1990 through 1992 SMRF outpatient and inpatient claims records to the 1990 summary file to define use of services form birth through 24 months of age. We decided on this study period because the time of the most intense use of primary care services is during the first 2 years of life, and after age 2, use of well-child services becomes infrequent. The children in the cohort were censored at 24 months of age, on the date of disenrollment from the Medicaid program, or enrollment in a prepaid managed care program. We excluded blind children and children with other disabilities because of their very small numbers, those who did not appear in the data until after age 1 month, and those who were enrolled in Medicaid managed care systems. The last were excluded because the SMRF system contains only the dollar amount of the monthly prepayment with no concomitant information on individual services, limiting the usefulness of these records.

Well-Child Visits and Immunizations

In the SMRF system, state-specific[a] and national (Current Procedural Terminology [CPT]-4 and *International Classification of Diseases, Ninth Revision [ICD-9]*[b]) procedure codes identify well-child visits; sick visits; and immunizations for diphtheria, pertussis, and tetanus (DPT), poliovirus vaccine (OPV), mumps, measles, rubella (MMR), and hemophilus influenzae type B (HiB).[15–17] Using these codes, we created an event-based file that pinpointed each service at the child's age on the date that the service was provided. When there were 2 well-child visits or 2 DPTs recorded on the same date, we counted them as one. When a sick visit and an immunization occurred on the same day, we counted the visit as a sick visit and a well visit to account for opportunistic preventive care.

The determination of the timeliness and number of well-child visits and immunizations was based on the 1988 AAP recommendations for health supervision.[18] These were 6 well-child visits by 12 months of (at ages 1, 2, 4, 6, 9, and 12 months) and another 3 visits evenly distributed through the second year of life and 4 DPTs (3 at 2-month intervals between 0 and 6 months of age and 1 at 15–18 months of age), 3 oral OPVs (2 between ages 0 and 6 months at least 2 months apart and 1 at 15–18 months of age), and 1 MMR and 1 HiB at 15–18 months of age. To allow for variability in visit timing, we defined broader time ranges for compliance on the basis of the above recommendations. Thus, children were deemed up-to-date if they had well-child visits within the following intervals: 1 visit by 3 months of age, 2 by 4 months of age, 3 by 6 months of age, 4 by 8 months of age, 5 by 11 months of age, 6 by 14 months of age, 7 by 17 months of age, and 8 by 20 months of age. When there were 2 or more well-child visits within a range, the extra visits were not counted. The visits had to be timed appropriately. For example, if there was no visit by 3 months of age but there were 2 visits by 4 months, then only one was counted. To be up-to-date with immunizations, the children had to have 1 DPT by 4 months of age; 2 DPTs and 1 OPV by 6 months of age; 3 DPTs and 2 OPVs by 12 months of age; and 4 DPTs, 3 OPVs, 1 MMR, and 1 HiB by 24 months of age.

[a]State-specific 1990 codes included the following—California: 9000-1, 90010, 90015, 90020-4, 90026, 90030, 90040, 90050, 90060, 90070, 90080, 90083-4, 12603-9, 12701-15, 12817-22, 12840-2, 12844, 12846, 12850, 12860, 90720-3, 12823-6, 00807, 00813, 00814, 00720, 83022, 83033, 85401, 85014, 85018, 85020-6, 85025, 85030-4, 81005, 81010, 81015-6, 85660, 83020, 86592-3, and 84128-9; Georgia: X9198, X9147, and Y0800-3; Michigan: 0X9010-19, 009877, 009888, 169522, 169525, 409040, 409912, 409950, 40000-1, 0Y60013, 169019, 0X8890, 88700-1, 88703, 884288534, and 70116.

[b]CPT-4/HCPCS codes included 90225, 90753-7, 90763-4, 90701-9, 90712-4, 90717-9, 90724-8, 90731-3, 90737, 90741-2, J2750, J1670, J6015, J6025, J6045, 85014, 85018, 85021, 85031, 81000, 81002, 86580, 86585, 83020, 83052, 87072, 87110, 84030-1, 88150, 86592, 83645, 83650, 83660, and 83670. ICD-9 codes included V03.5, V03.6, V03.7, V04.0, V04.2-.3, V04.6, V06.1, V06.3, V06.4, V20.1, V20.2, V210, V72.0, V72.1, and 721.2.

Avoidable Hospitalizations

We selected four common conditions that are amenable to prevention or amelioration and that have been used by other researchers as indictors of access to ambulatory care.[19] These included hospitalizations with the following ICD-9 codes—acute upper-respiratory infections: 460 (nasopharyngitis), 461 (acute sinusitis), 462 (acute pharyngitis), 463 (acute tonsillitis), 464 (acute laryngitis and tracheitis), and 465 (other acute upper respiratory infections); lower respiratory infection: 466 (acute bronchitis and bronchiolitis), 481 (pneumococcal pneumonia), 482 (other bacterial pneumonia), 483 (other microbial pneumonia), 485 (bronchopneumonia with unspecified organism), 486 (pneumonia with unspecified organism); gastroenteritis and dehydration: 009 (ill-defined intestinal infection), 276.0 (hyperosmolality/hypernatremia), 276.1 (hyposmolality/hyponatremia), 276.5 (volume depletion), 558.9 (other nonspecific gastroenteritis), 775.5 (transitory neonatal electrolyte disturbance); and asthma and chronic bronchitis: 491.21 (acute exacerbation of chronic obstructive pulmonary disease), 491.9 (unspecified chronic bronchitis), 493 (asthma). We also selected any hospitalization for acute injury and poisoning (ICD-9 521.1, 360.5–360.6, 376.6, 388.11, 800–994.9, 995.5–995.9, E800–E928.9, E950–E958.9, E960–E968.9, E980–E999, V71.4, V71.6 [excluding 855–859, 888–889, 898)] because anticipatory guidance for injury prevention is a component of the well-child visit. The injury codes exclude medical injuries.

Statistical Analysis

The analyses required the creation of 2 samples. The first consisted of children who appeared in the Medicaid files by age 1 month and were enrolled continuously in fee-for-service Medicaid for 24 months thereafter. This sample provided descriptive statistics of well-child services and sick visits. The second, larger, sample consisted of children who appeared in the Medicaid files by age 1 month and who were enrolled continuously until they became disenrolled from fee-for-service Medicaid, had an avoidable hospitalization, or were 24 months old. This sample was used to calculate hospitalization rates and was the base sample for the survival analysis.

Survival Analysis

The analysis measured adherence with recommended well-child care or immunizations for each child's first 2 years of life. To accommodate the concepts of adequate numbers of visits and immunizations with timeliness, we created preventive-care variables that expressed the child's status at any time (t) between age 1 month and the first avoidable hospitalization or, if the child did not have an avoidable hospitalization, the time when that each child attained 24 months of age or was disenrolled from Medicaid. We created a yes/no variable to indicate whether a child's well-child visits were up-to-date for age, meaning that the child had the correct number and timing (using the liberalized well-child visit schedule described previously) of well-child visits at time t. To account for sporadic well-child visits among children who were not up-to-date, we created another yes/no variable that measured timeliness of the most recent visit, defined as a well-child visit that occurred within 30 days of time t for children younger than 4 months, 60 days for ages 5 to 10 months, 90 days for ages 11 to 19 months, 120 days for 20 months, 150 days for 21 months, and 180 days if older than 22 months. A third yes/no variable that represented currency with immunizations was defined as being up-to-date with the liberalized immunization schedule cumulative described previously.

In the regression analysis (a Cox partial likelihood regression[20,21]), the outcome was the number of days from age 31 days to time t described above. We computed separate regression models for California, Georgia, and Michigan because of the differences in the Medicaid programs from state to state. For California, creation of the variables that represented preventive care increased the size of the analytic sample beyond the limit of our computing ability, prohibiting model estimation with the whole cohort. Instead, we used a nested case-control design for Califor-

nia in which cases were those children with an avoidable hospitalization and controls were a random sample of every sixteenth nonhospitalized child. The California regression consisted of 11 554 children with an avoidable hospitalization and 12 142 controls. To correct for informative sampling caused by selecting cases and controls based on the outcome, we used a weight of 16 for the nonhospitalized children.[22] The standard errors only approximated those of the full California cohort because of limitations in the statistical software. To validate the California standard errors derived from the nested case control model, we used the same approach for Georgia and Michigan cohorts using the case-weighted method and found that the standard errors were similar to those from the respective full sample analyses.

Because the outcome variable was avoidable hospitalization, it was necessary to control for chronic and acute illnesses among the children in the cohort. To do this, we used sick visits (defined as a visit with a diagnostic code indicating an illness) to control for the level of health of the children in the regression. We used average number of sick visits per week up to time *t* to adjust for chronic illness and a yes/no variable that indicated that a sick visit occurred within 30 days of time *t* to adjust for acute illness. A third yes/no variable indicated whether there was a hospitalization in the first month of life (excluding the birth hospitalization) to control for illness related to the neonatal period. Other control variables included in the regression were gender, race, and eligibility category (Aid to Families with Dependent Children [AFDC], other poverty, or medically needy). The Medicaid eligibility categories represent 2 income levels: poor (those who qualified for AFDC) and near poor (those who qualified for Medicaid under congressionally mandated expansions but were not poor enough to receive AFDC cash assistance). Finally, we linked county-level statistics to each child's record to control for area medical resources and regional poverty.[23,24] These included number of pediatricians and hospital beds per 10 000 county residents and percentage of families with incomes under the federal poverty level residing in each child's county.

RESULTS

There were 298 140 children in California, 52 223 children in Georgia, and 71 010 children in Michigan who were born in 1990 and enrolled in Medicaid sometime during their first year of life. We excluded from the California cohort 553 (0.2%) blind children or children with other disabilities, 17 (0.005%) with missing eligibility information, 3375 (1.1%) who initially were enrolled in prepaid managed care plans, and 88 356 (29.6%) for whom there was no evidence of fee-for-service Medicaid enrollment during the first 30 days of life. We excluded from the Georgia cohort 264 (0.5%) blind children or children with other disabilities and 8255 (15.8%) children for whom there was no evidence of fee-for-service Medicaid enrollment during the first 30 days of life. From Michigan, we excluded 84 (0.1%) blind children or children with other disabilities, 87 (0.1%) with missing eligibility information, 5287 (7.5%) who initially were enrolled in prepaid managed care plans, and 6964 (9.8%) for whom there was no evidence of fee-for-service Medicaid enrollment during the first 30 days of life. The final sample size was 205 839 children from California, 43 704 from Georgia, and 58 588 from Michigan, which was 69.0%, 83.7%, and 82.5%, respectively, of the original state samples. Those not selected for the analysis because they were enrolled in Medicaid after age 1 month did not differ from those selected by gender or race. However, the children in California and Georgia who were not selected for the analysis were more likely to be from the poorest group, the AFDC-eligible families (data not shown).

The major ethnic group among the California children was Hispanic (53%), among the Georgia children was black (57%), and among the Michigan children was white (58%; Table 1). Eligibility categories varied on the basis of each state's policies. For example, in Georgia, 71% of the children qualified for Medicaid under expansions to cover near-poor children compared with California (52%) and Michigan (34%). Compared with the baseline 1-month enrollment group, the children who stayed enrolled for 2 years were more likely to be black and from the poorest eligibility category.

Table 2 gives rates of well-child visits, immunizations, and sick visits among the children who remained in the cohort for 2 years. Although the rates

TABLE 1. Characteristics of a Cohort of Children Born in 1990 in California, Georgia, and Michigan and Enrolled in Medicaid by Age 1 Month*

Characteristic	Enrolled in Medicaid by Age 1 Month Baseline Sample			Enrolled in Medicaid by Age 1 Month and Enrolled Continuously for 2 Years		
	California	Georgia	Michigan	California	Georgia	Michigan
Number of children	205 839	43 704	58 588	112 783	30 199	41 346
Characteristic (from the SMRF; %)						
Female gender	49	49	49	49	49	49
Race/ethnicity						
White	24	41	58	25	34	53
Black	13	57	36	17	64	43
Asian/Pacific Islander†	7	1	0	9	0.4	–
Hispanic	53	2	4	47	15	1
Other	4	0.5	2	2	0.5	3
Medicaid eligibility category						
AFDC‡	48	29	66	64	36	77
Medically needy§	39	1	10	28	0.2	8
Other poverty§	13	70	24	8	64	15

AFDC indicates Aid to Families with Dependent Children.
* Children were not included in this table if they were blind or had another disability, enrolled in a prepaid managed care plan during their first 2 months of life, or had missing eligibility information.
† Asians in Michigan were categorized as other.
‡ AFDC is the lowest income Medicaid eligibility category.
§ Other poverty and medically needy categories included higher income children who qualified for Medicaid under expansion programs in the 1980s.

differed among the states, substantial numbers of children had 1 or fewer well-child visits (30% in California, 51% in Georgia, and 35% in Michigan). Similarly, few children had all of their DPTs by age 2 (15% in California, 21% in Georgia, and 10% in Michigan) or their OPV (22% in California, 28% in Georgia, and 16% in Michigan). The majority of children had frequent (7 or more) sick visits in all three states. There was almost no variation by race or ethnicity in rate of well-child visits or immunizations. In Michi-

TABLE 2. Well-Child Visits and Immunizations* by Race and Ethnicity at Age 24 Months Among a Cohort of Infants Born in 1990 in California, Georgia, and Michigan and Enrolled in Medicaid by 1 Month of Age

Parameter	White	Black	Hispanic	Asian/Pacific†	Other	Total
California						
Number of children continuously enrolled in Medicaid for 24 months	27 916	19 239	53 541	10 192	1895	112 783
0–1 well visits	29%	30%	30%	29%	35%	30%
2–4 well visits	40%	40%	40%	40%	38%	40%
5 or more well visits	31%	30%	30%	31%	27%	30%
0–2 sick visits	16%	17%	17%	16%	21%	17%
3–6 sick visits	22%	23%	23%	22%	24%	22%
7 or more sick visits	62%	60%	60%	62%	55%	61%
<2 DPT‡	47%	47%	48%	46%	53%	47%
2–3 DPTs	39%	39%	38%	19%	35%	37%
4 or more DPTs	15%	15%	14%	21%	12%	15%
<2 OPV‡	56%	56%	57%	56%	61%	57%
2 OPVs	21%	21%	21%	22%	19%	21%
3 or more OPVs	23%	22%	22%	22%	20%	22%
MMR‡	60%	59%	59%	61%	55%	59%
HiB‡	20%	20%	20%	20%	18%	20%
Georgia						
Number of children continuously enrolled in Medicaid for 24 months	10 363	19 257	309	107	163	30 199
0–1 well visits	51%	51%	50%	59%	53%	51%
2–4 well visits	34%	35%	28%	20%	25%	34%
5 or more well visits	15%	14%	22%	21%	22%	15%
0–2 sick visits	15%	16%	12%	15%	18%	16%
3–6 sick visits	22%	21%	20%	20%	27%	21%
7 or more sick visits	63%	63%	68%	65%	55%	63%
<2 DPT‡	37%	38%	34%	44%	39%	38%
2–3 DPTs	41%	42%	43%	45%	43%	41%
4 or more DPTs	21%	21%	23%	11%	18%	21%
<2 OPV‡	45%	45%	39%	49%	51%	45%
2 OPVs	26%	27%	28%	27%	25%	27%
3 or more OPVs	29%	28%	33%	24%	24%	28%
MMR‡	50%	49%	57%	51%	40%	49%
HiB‡	66%	65%	71%	64%	58%	66%
Michigan†						
Number of children continuously enrolled in Medicaid for 24 months	21 800	17 646	1361	0	539	41 346
0–1 well visits	34%	37%	31%		35%	35%
2–4 well visits	39%	48%	40%		39%	43%
5 or more well visits	27%	15%	29%		26%	22%
0–2 sick visits	14%	15%	13%		13%	14%
3–6 sick visits	16%	16%	15%		14%	16%
7 or more sick visits	70%	70%	72%		73%	70%
<2 DPT‡	56%	57%	55%		57%	56%
2–3 DPTs	34%	33%	34%		32%	33%
4 or more DPTs	11%	10%	11%		11%	10%
<2 OPV‡	61%	62%	61%		63%	61%
2 OPVs	23%	23%	23%		22%	23%
3 or more OPVs	16%	16%	16%		15%	16%
MMR‡	31%	30%	30%		30%	31%
HiB†	38%	38%	38%		38%	38%

HiB indicates *Haemophilus influenzae* type B.

* Codes for well-child visits and immunizations. State-specific 1990 codes included the following—California: 9000-1, 90010, 90015, 90020-4, 90026, 90030, 90040, 90050, 90060, 90070, 90080, 90083-4, 12603-9, 12701-15, 12817-22, 12840-2, 12844, 12846, 12850, 12860, 90720-3, 12823-6, 00807, 00813, 00814, 00720, 83022, 83033, 85401, 85014, 85018, 85020-6, 85025, 85030-4, 81005, 81010, 81015-6, 85660, 83020, 86592-3, and 84128-9; Georgia: X9198, X9147, and Y0800-3; Michigan: 0X9010-19, 009877, 009888, 169522, 169525, 409040, 409912, 409950, 40000-1, Y60013, 169019, 0X8890, 88700-1, 88703, 884288534, and 70116. CPT-4/HCPCS codes included 90225, 90753-7, 90763-4, 90701-9, 90712-4, 90717-9, 90724-8, 90731-3, 90737, 90741-2, J2750, J1670, J6015, J6025, J6045, 85014, 85018, 85021, 85031, 81000, 81002, 86580, 86585, 83020, 83052, 87072, 87110, 84030-1, 88150, 86592, 83645, 83650, 83660, and 83670. ICD-9 codes included V03.5, V03.6, V03.7, V04.0, V04.2-.3, V04.6, V06.1, V06.3, V06.4, V20.1, V20.2, V21.0, V72.0, V721.0, and 721.2.

† Asians and Pacific Islanders in Michigan were categorized as other.

‡ The prevailing AAP recommendations were 6 well-child visits by age 12 months (ages 1, 2, 4, 6, 9, and 12 months) and 3 visits evenly distributed through the second year of life. The schedule for immunizations was 4 DPTs (3 at 2-month intervals between 0 and 6 months and 1 between 15 and 18 months), 3 OPVs (2 between ages 0 and 6 months at least 2 months apart and 1 at 15–18 months), and 1 MMR and 1 HiB at 15–18 months.

gan, black children made fewer well-child visits than did white children.

The Kaplan-Meier estimate for avoidable hospitalization for the entire sample was 117/1000 children in the 3 states combined, 12.8/1000 with acute upper-respiratory infections, 48.1/1000 with acute bronchitis or pneumonia, 14.0/1000 with gastroenteritis or dehydration, and 28.3/1000 with an injury. The distribution of avoidable hospitalizations by diagnostic group did not vary substantially among the 3 states (data not shown). Georgia had the highest rate of avoidable hospitalizations (160.9/1000 children), followed by Michigan (120/1000) and California (70/1000). Boys had higher avoidable hospitalization rates than did girls (Table 3). In California and Michigan, black children had the highest rates of avoidable hospitalizations, but in Georgia, white children had higher rates. The AFDC group, the poorest category of children, had higher rates of avoidable hospitalizations overall.

The survival analysis indicated that being up-to-date for age with the AAP's recommended number of well-child visits was associated with a statistically significant reduction in risk of avoidable hospitalizations. In California, children who were up-to-date with their well-child visits had a 48% lower likelihood of experiencing an avoidable hospitalization (hazard ratio [HR]: 0.52; 95% confidence interval [CI]: 0.50–0.55), after controlling for proxies for illnesses, gender, race/ethnicity, Medicaid eligibility category, and local medical resources and poverty (Table 4). This finding was similar for the Georgia children (HR: 0.54; 95% CI: 0.50–0.58). In Michigan, the hazard ratio was higher (HR: 0.74; 95% CI: 0.69–0.79) but still statistically significant. A recent well-child visit among the children who were not up-to-date for age was associated with having fewer avoidable hospitalizations but not as strongly as being up-to-date (HR: 0.87; 95% CI: 0.82–0.92 in California; HR: 0.90; 95% CI: 0.83–0.97 in Georgia; and HR: 0.86; 95% CI: 0.78–0.94 in Michigan). Being up-to-date with immunizations was associated with fewer avoidable hospitalizations only in Michigan.

In the 3 states, the variables that represented health, male gender, and Medicaid eligibility (level of poverty indicator) were related to hospitalization (Table 4). In California and Michigan, black children were more likely to experience an avoidable hospitalization but were less likely in Georgia than whites. These associations were not as strong as the association with well-child visits or indicators of illness, suggesting a minor role for race; other risk factors held constant. Finally, having more pediatricians per 10 000 population was associated with fewer avoidable hospitalizations in Georgia (HR: 0.74; 95% CI: 0.72–0.76) and Michigan (HR: 0.92; 95% CI: 0.87–0.96).

TABLE 3. Rate per 1000* of Having an Avoidable Hospitalization Among a Cohort of Infants Born in 1990 in California, Georgia, and Michigan and Enrolled in Medicaid by 1 Month of Age

Parameter	California	Georgia	Michigan
Total avoidable hospitalizations†	70.1	160.9	120.3
Gender			
Female	58.2	146.8	103.4
Male	81.6	174.5	136.4
Race			
White	69.0	181.8	117.7
Black	83.9	147.0	127.3
Hispanic	67.2	113.7	106.7
Asian/Pacific Islander	69.9	57.6	-
Other‡	63.0	-	-
Eligibility status			
AFDC	84.7	174.7	132.0
Medically needy§	54.5	93.4	109.7
Other poverty	56.4	155.4	88.8

* This is the Kaplan-Meier estimated rate of first avoidable hospitalizations from age 31 days through age 24 months. Avoidable hospitalizations that occurred during the first month were used as control variables in the regression models (see Methods section).
† Includes the ICD-9 diagnostic groups tonsillitis, nasopharyngitis, sinusitis, laryngitis, epiglottitis, and tracheitis. ICD-9 codes 460-465.9; acute bronchitis, bronchiolitis, or bacterial pneumonia: ICD-9 codes 466, 481-483, 485, 486; asthma and chronic bronchitis: ICD-9 codes 491.21, 491.9, 493; gastroenteritis and dehydration: ICD-9 codes 009, 558.9, 276.0, 276.1, 276.5, 775.5; acute injury and poisoning: ICD-9 codes 521.1, 360.5-360.6, 376.6, 388.11, 800-994.9, 995.5-995.9, E800-E928.9, E950-E958.9, E960-E968.9, E980-E999, V71.4, V71.6. Exclude from above 855-859, 888-889, 898-899, 905-909, 994.6, 995.6-995.69, E808, E809, E839, E859, E870-E879, E889, E979, E989, and E990.2.
‡ There were not enough events in this group in Georgia or Michigan to compute a Kaplan-Meier estimate.
§ Other poverty and medically needy categories included higher income children who qualified for Medicaid under expansion programs in the 1980s.

DISCUSSION

This analysis revealed a statistically significant association between adherence to the periodic well-child visit schedule during the first 2 years of life and fewer potentially avoidable hospitalizations among a birth cohort of Medicaid-enrolled children in 3 states with large numbers of Medicaid-enrolled newborns. The association was present regardless of race or ethnicity, level of illness, gender, level of poverty, or local resources. Our results help substantiate conventional wisdom that has fueled efforts to ensure that poor children receive early periodic preventive care. The results of this research are consistent with findings from 2 other studies. A mid-1960s experiment that offered primary care to a group of poor families found that free comprehensive services increased physician use and reduced hospitalizations, and an evaluation of a Medicaid managed care program in Maryland found that the number of primary care visits was inversely associated with avoidable hospitalizations.[14,25] Neither of these studies examined specifically the concept of adherence to guidelines for pediatric care.

Evaluation of Medicaid expansions has shown that providing insurance increases use of pediatric preventive services among low-income families.[26] Utilization of health care services is a multidimensional phenomenon that involves more than financial access to care. Individual circumstances; family dynamics; social, cultural, political, and economic factors; provider characteristics; and the characteristics of health care systems all come into play to affect health behaviors that might improve use of pediatric child health care.[13] Although a study, such as the present one, that uses claims data cannot identify

TABLE 4. Proportional Hazards Survival Model Predicting the Likelihood of Being Hospitalized for an Avoidable Hospitalization Among a Cohort of Infants Born in 1990 in California, Georgia, and Michigan and Enrolled in Medicaid by 1 Month of Age

Factor	California*		Georgia		Michigan	
	HR	95% CI	HR	95% CI	HR	95% CI
Preventive care						
Well visits up-to-date for age†	0.52	0.50–0.55	0.54	0.50–0.58	0.74	0.69–0.79
Sporadic preventive care*	0.87	0.82–0.92	0.90	0.83–0.97	0.86	0.78–0.94
Immunizations up-to-date for age§	1.12	1.06–1.18	1.05	0.98–1.12	0.88	0.82–0.94
Control variables						
Average number of sick visits per week	2.76	2.65–2.89	2.03	1.90–2.17	2.77	2.58–2.98
Sick visit within the past 30 days	2.67	2.57–2.79	2.68	2.54–2.84	2.55	2.41–2.70
Hospitalized during the first month of life‖	1.48	1.25–1.75	1.38	1.16–1.64	1.22	0.99–1.51
Male gender¶	1.38	1.33–1.44	1.18	1.12–1.24	1.35	1.28–1.42
Race/ethnicity#						
Black	1.14	1.07–1.21	0.85	0.81–0.90	1.14	1.07–1.21
Asian/Pacific Islander	0.91	0.85–0.99	0.65	0.36–1.17	–	
Hispanic	1.14	1.09–1.20	0.87	0.68–1.11	1.08	0.93–1.25
Other	1.22	1.09–1.37	1.17	0.94–1.45	0.83	0.66–1.04
Medicaid eligibility category**						
Medically needy	0.65	0.62–0.68	0.38	0.23–0.63	0.88	0.80–0.96
Other poverty	0.62	0.58–0.66	0.88	0.83–0.92	0.74	0.69–0.80
Percentage of families living under the federal poverty level‡	1.00	1.00–1.01	1.03	1.02–1.03	1.00	0.99–1.01
Number of pediatricians/10 000 county residents‡	0.97	0.93–1.01	0.74	0.72–0.76	0.92	0.87–0.96
Number of hospital beds/10 000 county residents††	1.01	0.99–1.05	1.03	1.02–1.04	1.03	1.00–1.05

* Because the size of the California data set made it impossible to run a partial likelihood model with the whole sample, a nested case-control design was used (see Methods section). The California regression consisted of 11 554 children with an avoidable hospitalization and 12 142 controls, which was 1 of 16 of the children with no avoidable hospitalization. The models used the entire Georgia and Michigan samples.

† The child was up-to-date if he or she had 1 visit by age 3 months, 2 by age 4 months, 3 by age 6 months, 4 by age 8 months, 5 by age 11 months, 6 by age 14 months, 7 by age 17 months, and 8 by age 20 months.

‡ If the child was not up-to-date by the above criteria, a sporadic well visit was defined as a recent well visit that occurred within 30 days if child <4 months of age, 60 days if 4 to 10 months, 90 days if 11 to 19 months, 120 days if 20 months, 150 days if 21 months, and 180 days if 22 months or older.

§ This variable was based on a modification of the 1988 AAP schedule of immunizations. Children were up-to-date if they had 1 DPT by age 4 months, 2 DPTs and 1 OPV by age 6 months, 3 DPTs and 2 OPVs by 12 months, and 4 DPTs, 3 OPVs, 1 MMR, and 1 HiB by 24 months.

Refers to any hospitalization not associated with birth.

¶ Female is the reference category.

White is the reference category.

** AFDC eligibility category is the reference.

†† Source: Office of Research and Planning, Bureau of Health Professions, U.S. Department of Health and Human Services, the Area Resource File, 1992 version. These data were linked to each child's record by county of birth.

either barriers or forces that affect them, other studies have. These include education, minority status, use of other health services, birth order, family size, maternal age and age of the child, family support system, a usual source of care, parental misinformation, private physician as a provider, scheduling and transportation difficulties, long waiting room times or care perceived to be unresponsive or disrespectful, social disenfranchisement and racial discrimination, level of Medicaid reimbursement, and being in a health plan with a Medicaid primary care provider.[14,27–41] Because of the limitations of Medicaid data, this analysis cannot clarify the pathway that underlies the association that we found between well-child visits and reduced avoidable hospitalization. Thus, it is not possible to attribute our findings to the content of the well-child visits. Instead, this study may be measuring intangible factors related to the health of families and relationships between the family and the pediatric provider that may act on adherence and avoidable hospitalizations.

Most of the children in this study had inadequate levels of well-child care and immunizations, a finding consistent with studies of well-child care and immunization prevalence among poor children 10 years ago. Evidence suggests that things are improving. For example, a more recent study that used 1994–1995 enrollment records from a New York Medicaid managed care system found that only 36% of the Medicaid children younger than 2 years received all of the recommended visits, findings not dissimilar from our 1990–1992 findings.[42] However, a North Carolina study that followed a 1994–1995 birth cohort for 2 years found that 75% of the Medicaid children had at least 5 well-child visits by age 2.[28] In addition, government programs may have improved immunization levels substantially. National estimates indicated that in 1996, vaccination coverage levels for DPT were over 70% and for poliovirus were nearly 90% among poor children younger than 3 years.[43] There is concern that providing immunizations outside the context of the well-child visit for children younger than 2 years will provide a disincentive for compliance with early well-child visit schedules.[43] Alternatively, as the North Carolina data suggest, levels of preventive

care may be improving, perhaps because of immunization efforts. The authors are currently analyzing more recent Medicaid cohorts in more states for well-child levels, screenings, and immunizations.

Unlike results from national data sets that suggest that black and Hispanic children use fewer preventive services at all income levels, we did not find any striking racial/ethnic disparities in the use of preventive services in the states in this analysis.[10] Rates of avoidable hospitalizations did vary by race and ethnicity, but not in a predictable manner. State, gender, and poverty level had more marked effects on hospitalization. The results suggest that the effects of race and ethnicity cannot be predicted and that instead, state policies and programs, demographics other than race, and availability of health resources may be more important predictors of use of health services.

Other factors were associated with avoidable hospitalizations. Consistent with most other studies, greater poverty was associated consistently with increased avoidable hospitalization.[9] The two Medicaid categories—medically needy and other poverty—are a result of expansions that occurred in the 1980s that allowed children whose families had incomes that were higher than those in families that received AFDC benefits to become Medicaid eligible. Thus, children who were eligible under these two categories were less poor than the AFDC group and were less likely to experience an avoidable hospitalization than the AFDC reference group.

As expected, the variables associated with acute and chronic illness were the most important predictors of avoidable hospitalization. Timely and adequate immunization levels, which may be markers for preventive care use, were not associated independently with hospitalizations, except in Michigan. Immunizations may be indirect markers for well-child visits.

Pediatric preventive care intervention research, which has been concerned primarily with improving immunization coverage, has demonstrated that many efforts to immunize children work.[44–47] Improved immunization coverage is associated with improved preventive care but does not absolutely ensure that children will receive other aspects of preventive care. Care should be taken to ensure that efforts to immunize children in venues other than the primary care setting do not preclude the periodic health supervision visit.

There are a number of cautions in interpreting the findings reported in this article. First, there is substantial attrition in Medicaid enrollment. It was for this reason that we chose to evaluate preventive care effectiveness during the first 2 years, which is the time of the lowest Medicaid disenrollment and the highest concentration of use of preventive services. However, because of the attrition, we cannot determine whether preventive care has benefits after the first 2 years of life. Second, we chose the AAP guidelines for health supervision because of their general acceptance in the pediatric community and by state Medicaid programs. However, our analysis does not provide specific endorsement of the AAP schedule over others because these data do not support a precise assessment of >5 well-child visits in 2 years. This is because few children in this cohort made more than this number of visits. Fourth, we dropped nearly 30% of California children because they did not have utilization information during the first few months after birth, but because we controlled for income category, this did not change the effect of income on the California cohort. Finally, we know anecdotally that health care and immunizations are provided to Medicaid-enrolled children that are never billed, either because mothers do not remember to bring their Medicaid cards and are provided with care that is not billed to Medicaid, providers do not bother to bill for the injections, or the children receive care in settings with state or local funding. Thus, our levels of health service use probably are underestimates of the true utilization levels in the early 1990s. However, the levels of preventive care service use from other studies of pediatric preventive care service use in the early 1990s are close to the figures presented here.[48–50] Despite these limitations, the association between preventive care and a reduction in avoidable hospitalizations was robust and was consistent across the states and racial and ethnic groups.

The results of this study provide evidence that a series of early well-child visits prevents avoidable hospitalizations among children in Medicaid, despite race, ethnicity, region, and level of poverty. These findings are particularly timely in light of the recent implementation of the Children's Health Insurance Program, which aims to provide insurance coverage for all U.S. children who previously were not eligible for Medicaid coverage. Although the Medicaid data do not allow us to explain the mechanism of the associations that we found, the broad policy implication is that every child needs to be in a health care system in which they can be assured of continuous primary care, the providers actively engage in outreach, a personal bond is formed between the physician and the family, and education and support are provided to families. The Children's Health Insurance Program, enacted by the 1997 Balanced Budget Act, is increasing the effort to provide health coverage for every uninsured child in the United States. However, we must work harder to ensure that these children are receiving the care that they need for a healthy life.

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REFERENCES

1. National Center for Health Statistics. *Health, United States, 1998, With Socioeconomic Status and Health Chartbook*. Hyattsville, MD: National Center for Health Statistics; 1998
2. Casey P, Sharp M, Loda F. Child-health supervision for children under 2 years of age: a review of its content and effectiveness. *J Pediatr*. 1979;95:1–9
3. American Academy of Pediatrics. *Recommendations for Preventive Health Care of Children and Youth. News and Comments*. Evanston, IL: American Academy of Pediatrics; 1974;25(6)

4. American Academy of Pediatrics. *Guidelines for Health Supervision III*. Elk Grove Village, IL: American Academy of Pediatrics Publications; 1997
5. Montgomery LE, Kiely JL, Pappas G. The effects of poverty, race, and family structure on US children's health: data from the NHIS, 1978 through 1980 and 1989 through 1991. *Am J Public Health*. 1996;86: 1401–1405
6. Dubos RJ. *Mirage of Health: Utopias, Progress, and Biological Change*. New York, NY: Harper; 1959
7. Pappas G, Queen S, Hadden W, Fisher G. The increasing disparity in mortality between socioeconomic groups in the United States, 1960 and 1986. *N Engl J Med*. 1993;329:103–109
8. Weissman JS, Gatsonis C, Epstein AM. Rates of avoidable hospitalization by insurance status in Massachusetts and Maryland. *JAMA*. 1992; 268:2388–2394
9. Halfon N, Newacheck PW, Wood DL, St. Peter RF. Routine emergency department use for sick care by children in the United States. *Pediatrics*. 1996;98:28–34
10. Newacheck PW, Hughes DC, Stoddard JJ. Children's access to primary care: differences by race, income, and insurance status. *Pediatrics*. 1996; 97:26–32
11. Newacheck PW, Starfield B. Morbidity and use of ambulatory care services among poor and nonpoor children. *Am J Public Health*. 1988;78: 927–933
12. Halfon N, Newacheck PW. Childhood asthma and poverty: differential impacts and utilization of health services. *Pediatrics*. 1993;91:56–61
13. United States Congress, House Committee on Energy and Commerce, Subcommittee on Health and the Environment. *Healthy Children, Investing in the Future*. Washington, DC: US Government Printing Office; 1988
14. Gadomski A, Jenkins P, Nichols M. Impact of a Medicaid primary care provider and preventive care on pediatric hospitalization. *Pediatrics*. 1998;101(3). URL: http://www.pediatrics.org/cgi/content/full/101/3/e1
15. US Department of Health and Human Services, Public Health Service, Health Care Financing Administration. *The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)*. Washington, DC: US Department of Health and Human Services, Public Health Service, Health Care Financing Administration; 1980
16. American Medical Association. *Physicians' Current Procedural Terminology: CPT*. Chicago, IL: The Association; c1973–c1997
17. Herz EJ, Sredl K, Albers, LA. *Trends in the Use of EPSDT and Other Health Care Services by Children Under Medicaid, 1989 and 1992; Year 2 Report: 1996 Technical Report to the Health Care Financing Administration*. Washington, DC: US Department of Commerce. National Technical Information Service, 1996 Publ. No. PB97-165112INZ
18. American Academy of Pediatrics, Committee on Infectious Diseases. *Report of the Committee on Infectious Diseases*. Elk Grove Village, IL: American Academy of Pediatrics; 1988
19. Rosenblatt RA, Moscovice IS. The physician as gatekeeper. Determinants of physicians' hospitalization rates. *Med Care*. 1984;22:150–159
20. Cox DR. Partial likelihood. *Biometrika*. 1975;62:269–276
21. SAS Institute, Inc. *Technical Report P-217, SAS/STAT Software. The PHREG Procedure. Version 6*. Cary, NC: SAS Institute, Inc; 1991
22. Binder DA. Fitting Cox's proportional hazard models from survey data. *Biometrika*. 1992;79:139–147
23. Billings J, Teicholz N. Uninsured patients in District of Columbia hospitals. *Health Aff (Millwood)*. 1990;9:158–165
24. Office of Research and Planning, Bureau of Health Professions, US Department of Health and Human Services. *The Area Resource File*. Washington, DC: Office of Research and Planning, Bureau of Health Professions, US Department of Health and Human Services ; 1992
25. Alpert JJ, Heagarty MC, Robertson L, Kosa J, Haggerty RJ. Effective use of comprehensive pediatric care. Utilization of health resources. *Am J Dis Child*. 1968;116:529–533
26. Short PF, Lefkowitz DC. Encouraging preventive services for low-income children. The effect of expanding Medicaid. *Med Care*. 1992;30: 766–780
27. Ronsaville DS, Hakim RB. Well child care in the United States: racial differences in compliance with guidelines. *Am J Public Health*. 2000;90: 1436–1443
28. Freed GL, Clark SJ, Pathman DE, Schectman R. Influences on the receipt of well-child visits in the first two years of life. *Pediatrics*. 1999;103: 864–869
29. Strobino D, Keane V, Holt E, Hughart N, Guyer B. Parental attitudes do not explain underimmunization. *Pediatrics*. 1996;98:1076–1083
30. Cornelius LJ. Barriers to medical care for white, black, and Hispanic American children. *J Natl Med Assoc*. 1993;85:281–288
31. Cohen JW, Cunningham PJ. Medicaid physician fee levels and children's access to care. *Health Aff (Millwood)*. 1995;14:255–262
32. Riportella-Muller R, Selby-Harrington ML, Richardson LA, Donat PL, Luchok KJ, Quade D. Barriers to the use of preventive health care services for children. *Public Health Rep*. 1996;111:71–77
33. Moore P, Hepworth JT. Use of perinatal and infant health services by Mexican- American Medicaid enrollees. *JAMA*. 1994;272:297–304
34. Pierce C, Goldstein M, Suozzi K, Gallaher M, Dietz V, Stevenson J. The impact of the standards for pediatric immunization practices on vaccination coverage levels. *JAMA*. 1996;276:626–630
35. Wood D, Donald-Sherbourne C, Halfon N, Tucker MB, Ortiz V, Hamlin JS, Duan N, Mazel RM, Grabowsky M, Brunell P, et al. Factors related to immunization status among inner-city Latino and African-American preschoolers. *Pediatrics*. 1995;96:295–301
36. Bobo JK, Gale JL, Thapa PB, Wassilak SG. Risk factors for delayed immunization in a random sample of 1163 children from Oregon and Washington. *Pediatrics*. 1993;91:308–314
37. Pappas G, Hadden WC, Kozak LJ, Fisher GF. Potentially avoidable hospitalizations: inequalities in rates between US socioeconomic groups. *Am J Public Health*. 1997;87:811–816
38. Moore P, Fenlon N, Hepworth JT. Indicators of differences in immunization rates of Mexican American and white non-Hispanic infants in a Medicaid managed care system. *Public Health Nurs*. 1996;13:21–30
39. Snowden LR, Libby A, Thomas K. Health-care-related attitudes and utilization among African American women. *Womens Health*. 1997;3: 301–314
40. Gary F, Campbell D, Serlin C. African American women. Disparities in health care. *J Fla Med Assoc*. 1996;83:489–493
41. Abbotts B, Osborn LM. Immunization status and reasons for immunization delay among children using public health immunization clinics. *Am J Dis Child*. 1993;147:965–968
42. Byrd RS, Hoekelman RA, Auinger P. Adherence to AAP guidelines for well-child care under managed care. *Pediatrics*. 1999;104:536–540
43. CDC. Vaccination coverage by race/ethnicity and poverty level among children aged 19–35 months—United States, 1996. *MMWR Morb Mortal Wkly Rep*. 1997;46:963–968
44. Colombo TJ, Freeborn DK, Mullooly JP, Burnham VR. The effect of outreach workers' educational efforts on disadvantaged preschool children's use of preventive services. *Am J Public Health*. 1979;69:465–468
45. Linkins RW, Dini EF, Watson G, Patriarca PA. Effectiveness of computer-generated telephone messages in increasing clinic visits. *Arch Pediatr Adolesc Med*. 1995;149:902–905
46. Waterman SH, Hill LL, Robyn B, Yeager KK, et al. A model immunization demonstration for preschoolers in an inner-city barrio, San Diego, California, 1992–1994. *Am J Prev Med*. 1996;12(4 suppl):8–13
47. Brown J, Melinkovich P, Gitterman B, Ricketts S. Missed opportunities in preventive pediatric health care. Immunizations or well-child care visits? *Am J Dis Child*. 1993;147:1081–1084
48. Szilagyi PG, Rodewald LE, Humiston SG, Fierman AH, Cunningham S, Gracia D, Birkhead GS. Effect of 2 urban emergency department immunization programs on childhood immunization rates. *Arch Pediatr Adolesc Med*. 1997;151:999–1006
49. Watson JM, Kemper KJ. Maternal factors and child's health care use. *Soc Sci Med*. 1995;40:623–628
50. Mustin HD, Holt VL, Connell FA. Adequacy of well-child care and immunizations in US infants born in 1988. *JAMA* 1994;272:11